STRING COSMOLOGY

String Cosmology

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At present only String Theory (ST) treats gravity consistently with quantum mechanics. In the low energy limit ST gives back a Brans-Dicke version of General Relativity, described by the action [1]

$$S = \int d^D x \sqrt{g} \left\{ -\frac{1}{2\kappa^2} e^{-\Phi} \left[R + (\partial\Phi)^2 + V \right] + \mathcal{L}_{\rm m}[g, \psi] \right\} \qquad (1)$$

where Φ is the dilaton field and $\mathcal{L}_{\rm m}$ represents a matter source term.

The cosmological equations, obtained from (1) for a homogeneous and spatially flat background and a matter contribution in the form of string gas with an energy-momentum tensor typical of a perfect fluid, are characterized by a symmetry called *Scale Factor Duality* (SFD) [2]. This symmetry naturally introduces a minimal length scale, suggesting then a possible solution to the singularity problem (SP) [3]. Really, we find [4] that, besides offering a natural solution to the SP, ST strongly modifies the standard lore of the cosmological evolution of the early universe. In particular, we report here an example where the early history of the visible universe is characterized by a smooth transition **expansion-contraction-expansion** (fig. 1).

In our solution the **outstanding problem of multi-dimensional and scalar-tensor cosmologies**, i.e. to keep *constant* Newton's constant, is automatically solved. In fact, as shown in fig. 2, the combination $G_N \sim b^{-n} e^{\Phi}$ (b is the scale factor of the n-dimensional internal space), after experiencing a non-trivial dynamics, converges towards a constant value. At the same time the internal radius stabilizes too and with it all the fundamental constants of physics which depend on it. The external scale factor, $a(t)$, before converging to the standard radiation dominated solution, displays, see fig. 3, three different phases of accelerated evolution (expansion-contraction-expansion). As accelerated contraction is equivalent to accelerated expansion (inflation) for the solution of the kinematical problems [5], our scenario naturally offers a suitable framework for the realization of *multiple-inflation*, a mechanism for breaking the scale invariance in the pertur-

FIGURE 1.

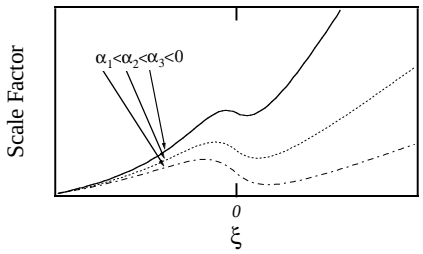


FIGURE 2.

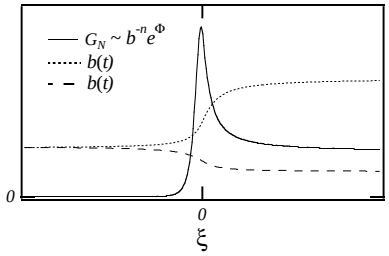
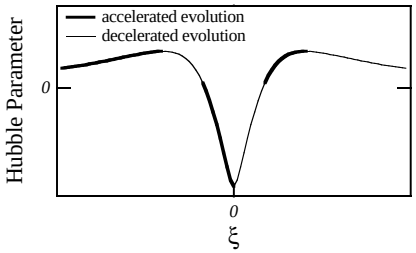


FIGURE 3.



bation spectrum.

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